PATENT ABSTRACTS OF JAPAN

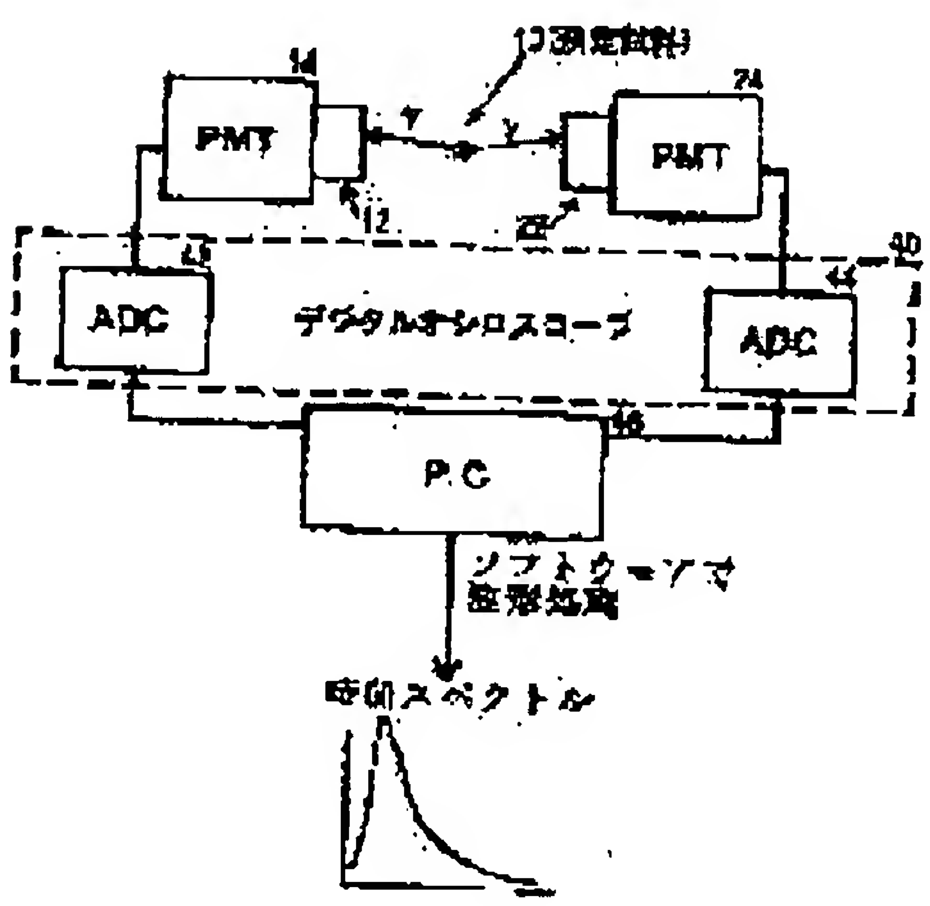
(11)Publication number : **2003-215251**
(43)Date of publication of application : **30.07.2003**

(51)Int.Cl. G01T 1/17
G01T 1/172
// G01T 1/30

(21)Application number : **2002-011921**
(22)Date of filing : **21.01.2002**

(71)Applicant : **SUMITOMO HEAVY IND LTD**
SAITO HARUO
HYODO TOSHIO
(72)Inventor : **SAITO HARUO**
HYODO TOSHIO
NAKAJO AKINOBU

(54) POSITRON LIFE-MEASURING METHOD AND APPARATUS



(57)Abstract:
PROBLEM TO BE SOLVED: To improve the time resolution of a positron life-measuring apparatus for improving time measurement accuracy, and at the same time to improve a count rate per unit time for reducing the measurement time.
SOLUTION: Gamma rays that are emitted with the development of extinction of positrons are detected, the detected waveform signal is digitized, and the digitized waveform signal is processed, thus obtaining a time spectrum with a time resolution of 200 ps or less.

LEGAL STATUS
[Date of request for examination] 21.08.2003
[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	3903112
[Date of registration]	19.01.2007
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

CLAIMS

[Claim(s)]
[Claim 1] The positive electron life measuring method which detects the gamma ray taken out with generating and disappearance of positive electron, digitizes the this detected wave signal and is characterized by processing the wave signal which this digitized and obtaining a time amount spectrum by 200 or less ps of time resolution.
[Claim 2] The positive electron life measuring method which detects independently the gamma ray taken out with generating and disappearance of positive electron with two or more gamma ray detection means, respectively, digitizes the this detected wave signal and is characterized by processing the wave signal which this digitized and obtaining a time amount spectrum by 200 or less ps of time resolution.
[Claim 3] The positive electron life measuring method which detects the gamma ray taken out with generating and disappearance of positive electron with two or more gamma ray detection means of both, and digitizes the this detected wave signal, and it is at the positive electron's generating and disappearance time, and distinction processing of the wave signal which this digitized is carried out, and is characterized by obtaining a time amount spectrum by 200 or less ps of time resolution.
[Claim 4] The positive electron life measuring method according to claim 1 to 3 characterized by considering timing which calculated the peak value and became a predetermined rate to this peak value as a positive electron's generating and disappearance time after graduating said digitized wave signal.
[Claim 5] The positive electron life measuring device characterized by having a gamma ray detection means to detect the gamma ray taken out with generating and disappearance of positive electron, a digitization means to digitize the this detected wave signal, and a waveform analysis means to process the wave signal which this digitized and to obtain a time amount spectrum by 200 or less ps of time resolution.
[Claim 6]
The positive electron life measuring device according to claim 5 characterized by said waveform analysis means including a smoothing means to graduate said digitized wave signal, a peak value detection means to calculate the peak value, and the timing detection means that considers timing from which it became a predetermined rate to this peak value as a positive electron's generating and disappearance time.

[Claim 7] The positive electron life measuring device according to claim 5 or 6 characterized by trying to detect independently the gamma ray which two or more said gamma ray detection means are established, and is taken out with generating and disappearance of positive electron, respectively.
[Claim 8] The positive electron life measuring device according to claim 5 or 6 characterized by trying to both detect the gamma ray which two or more said gamma ray detection means are established, and is taken out with generating and disappearance of positive electron.
[Claim 9] The positive electron life measuring device according to claim 7 or 8 characterized by forming said two gamma ray detection means in the location which counters on both sides of a sample.
[Claim 10] The positive electron life measuring device according to claim 8 with which said three gamma ray detection means are characterized by being arranged in the shape of abbreviation for T characters focusing on a sample.
[Claim 11] The positive electron life measuring device according to claim 8 with which said four gamma ray detection means are characterized by being arranged in the shape of an abbreviation cross joint focusing on a sample.
[Claim 12] The positive electron life measuring device according to claim 8 to 11 characterized by having further a coincidence detection means for incorporating the detected wave signal for said digitization means only when all of the output of two or more of said gamma ray detection means occur in predetermined time.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to a positive electron life measuring method and equipment, especially, raises the counting rate per unit time amount, and relates to the positive electron life measuring method and equipment of a super-high resolution which can shorten the measuring time while improving time resolution and improving the precision of timing measurement.
[0002]
[Description of the Prior Art] As the conventional measuring device which measures the life of positive electron is shown in drawing 1 Opposite arrangement was carried out at the both sides of the test portion 10 (refer to drawing 2) which sandwiched source of 22Na positive electron 10A by sample (for example, plate of copper which annealed) 10B. the generating side scintillator 12 which catches the nucleus gamma ray of 1.275MeV(s) from source of positive electron 10A, and is changed into light -- and The disappearance side scintillator 22 which the positive electron which disappeared in sample 10B takes out and which catches the positron annihilation gamma ray of 0.511MeV, and is changed into light, The photomultiplier tubes 14 and 24 by the side of generating for changing into an electrical signal the light generated in said scintillators 12 and 22, respectively, and disappearance (PMT), From the wave signal (refer to drawing 3) from said PMT 14 and 24 with which peak value P and a wave (half-value width W) change each time The constant fraction differential discriminators 16 and 26 of an analog for taking out the timing signal which shows a positive electron's generating or

disappearance time (CFD), Even if it delays only predetermined time (for example, 10ns) certainly and it has dispersion in the time resolution of equipment, the output by the side of [CFD26] disappearance With the delay circuit (Delay) 28 for measuring certainly time difference with the output by the side of [CFD16] generating, the start signal outputted from said generating side CFD16, and the stop signal outputted from said delay circuit 28 It has the time difference wave height transducer (TAC) 30 for making the histogram (a time amount spectrum being called) of a life spectrum as shown in drawing 4 and the multi-channel analyzer (MCA) 32, or the time amount / digital converter (TDC).

[0003] In order that source of positive electron 10A in said test portion 10 may take out the nucleus gamma ray of 1.275MeV(s) at the same time it takes out positive electron e+ as shown in drawing 2 , it is changing this into light by the generating side scintillator 12, and changing into an electrical signal by PMT14, and the time amount to which positive electron was born understands it.

[0004] The time amount to which positive electron disappeared can be understood by changing into light the positron annihilation gamma ray of 0.511MeV(s) which the positive electron which disappeared in sample 10B takes out with the disappearance side scintillator 22 on the other hand, and changing into an electrical signal by PNT24.

[0005] Therefore, the life of positive electron can be measured by acquiring a stop signal with the signal which acquires a start signal from the signal acquired by the generating side scintillator 12, and is acquired from the disappearance side scintillator 22, and measuring the time difference (for example, less than 50ns) by TAC30.

[0006] Since many positive electron is generated, it can measure an average life by taking out the histogram of a life spectrum as shown in drawing 4 .

[0007]

[Problem(s) to be Solved by the Invention] However, conventionally, the half-value width of time resolution is 200ps extent in the case of being the best, and sufficient time resolution was not able to be obtained. Furthermore, it also had the trouble that the counting rate per unit time amount was low, and the measuring time started.

[0008] It makes it a technical problem to raise the counting rate per unit time amount, and to enable compaction of the measuring time while this invention was made so that it may cancel said conventional trouble, it improves time resolution and improves the precision of timing measurement.

[0009]

[Means for Solving the Problem] The gamma ray taken out with generating and disappearance of positive electron is detected, this invention digitizes the this detected wave signal, and as it processes the wave signal which this digitized and obtains a time amount spectrum by 200 or less ps of time resolution, it solves said technical problem.

[0010] Moreover, two or more gamma ray detection means detect independently the gamma ray taken out with generating and disappearance of positive electron, respectively, the this detected wave signal is digitized, and as the wave signal which this digitized is processed and a time amount spectrum is obtained by 200 or less ps of time resolution, similarly said technical problem is solved.

[0011] Moreover, two or more gamma ray detection means of both detect the gamma ray taken out with generating and disappearance of positive electron, the this detected wave signal is digitized, and as it is at the positive electron's generating and disappearance

time, distinction processing of the wave signal which this digitized is carried out and a time amount spectrum is obtained by 200 or less ps of time resolution, similarly said technical problem is solved.

[0012] Moreover, after graduating said digitized wave signal, the peak value is calculated and it is made to consider timing which became a predetermined rate to this peak value as a positive electron's generating and disappearance time.

[0013] This invention solves said technical problem by having a gamma ray detection means to detect the gamma ray taken out with generating and disappearance of positive electron in a positive electron life measuring device again, a digitization means to digitize the this detected wave signal, and a waveform analysis means to process the wave signal which this digitized and to obtain a time amount spectrum by 200 or less ps of time resolution.

[0014] Moreover, it is made for said waveform analysis means to include a smoothing means to graduate said digitized wave signal, a peak value detection means to calculate the peak value, and the timing detection means that considers timing from which it became a predetermined rate to this peak value as a positive electron's generating and disappearance time.

[0015] Moreover, two or more said gamma ray detection means are established, and the gamma ray taken out with generating and disappearance of positive electron is detected independently, respectively.

[0016] Moreover, two or more said gamma ray detection means are established, and the gamma ray taken out with generating and disappearance of positive electron is both detected.

[0017] Moreover, said two gamma ray detection means are formed in the location which counters on both sides of a sample.

[0018] Or said three gamma ray detection means are arranged in the shape of abbreviation for T characters focusing on a sample.

[0019] Moreover, said four gamma ray detection means are arranged in the shape of an abbreviation cross joint focusing on a sample.

[0020] Moreover, only when all of the output of two or more of said gamma ray detection means occur in predetermined time, it enables it to save memory space by having further a coincidence detection means for incorporating the detected wave signal for said digitization means.

[0021]

[Embodiment of the Invention] With reference to a drawing, the operation gestalt of this invention is explained to a detail below.

[0022] First, the 1st which caught the incidence of positive electron, the nucleus gamma ray (1.275MeV) (it uses for a start signal) from 22Na which appears in coincidence, and one positron annihilation gamma ray (0.511MeV) (it uses for a stop signal) thru/or the 4th operation gestalt are explained.

[0023] As the 1st operation gestalt of this invention is shown in drawing 5 , have arranged it on both sides of a test portion 10 as usual. The output by the side of [PMT / 24] disappearance which detects the light generated in the generating side PMT 14 which detects the light generated in the generating side scintillator (for example, BaF2) 12, and the disappearance side scintillator (for example, BaF2) 22 It both digitizes using the high-speed digital oscilloscope 40 or high-speed digitizers (ADC) 42 and 44. Data for

example, by transmitting to a personal computer (PC) 46 and performing wave processing by software A time amount spectrum as shown in drawing 4 is obtained.
[0024] 10A of the source of 22Na positive electron of radioisotope (RI) is inserted by sample 10B of the measuring object, and said test portion 10 is installed in the line source 1 sample section, as shown in drawing 2 .
[0025] One side 14 of said PMT catches the nucleus gamma ray (1.275MeV) from source of positive electron 10A, and another side 24 catches a positron annihilation gamma ray (0.511MeV).
[0026] the output wave of said PMT 14 and 24 -- each time -- peak value and a form -- differing -- for example, a predetermined wave -- applying -- it is difficult to acquire the timing signal at the generating and disappearance time. So, with this operation gestalt, in case a wave is analyzed with PC46, as shown in drawing 6 , it graduates by step 100 first, covering a filter. If the wave after covering X (i) and a filter for the wave before covering a filter, for example as a filter is made into X' (i), using a degree type, it is made to become blunt in the sum total of four points (X (i), X (i+1), X (i+2), X (i+3)), and can graduate.
[0027]
$X'(i) = X(i)+X(i+1)+X(i+2)+X(i+3)$
-- (1)
[0028] Subsequently, at step 102, as shown in drawing 7 , it asks for wave-like peak value (peak value) P after covering a filter.
[0029] Subsequently, at step 104, the wave behind a filter has the time amount which crosses the predetermined rate T to peak value P, for example, 25% of threshold, and considers as the time of concentration (at namely, positive electron's generating or disappearance time) of a gamma ray.
[0030] Subsequently, at step 116, the time amount from the incidence of positive electron to [from the difference of the timing by the side of / PMT / 24 / disappearance] disappearance can be acquired the generating side PMT 14.
[0031] Therefore, if the above is repeated and the histogram of time amount is made from step 108, a positron annihilation life spectrum as shown in drawing 4 will be obtained.
[0032] In addition, in (1) type, although all of the multiplier of four points were set to 1 and it was made into the weighting with same each point, it is also possible to raise the central weight of two points, using a weighting multiplier as 1:2:2:1, for example. Moreover, it is also possible for the number of points not to be limited to four points, either, but to graduate it by three or less points or five points or more.
[0033] In this operation gestalt, since a generating side gamma ray (1.275MeV) is caught by one PMT12, a start signal is acquired, a disappearance side gamma ray (0.511MeV) is caught by PMT24 of another side like the conventional example shown in drawing 1 and he was trying to acquire a stop signal, processing of PC46 is comparatively easy.
[0034] In addition, he catches the gamma ray of 1.275MeV, and the gamma ray of 0.511MeV(s), and is trying to distinguish a start and a stop by two PMT 14 and 24 with both the 2nd operation gestalten of this invention later in the case of the waveform analysis in PC46.
[0035] If it does in this way, compared with the 1st operation gestalt, a counting rate will improve twice and a reading per second's will improve twice.
[0036] On the other hand, since CFD 16 and 26 of an analog was used conventionally, as

CFD16 caught the gamma ray of 1.275MeV(s) and the gamma ray of 0.511MeV(s) caught in CFD26, when it needed to set up beforehand, and the gamma ray of 0.511MeV(s) went into CFD16 and the gamma ray of 1.275MeV(s) went into a setup and reverse in advance of measurement CFD26, it was not able to detect.

[0037] Next, the 3rd operation gestalt of this invention is explained to a detail.

[0038] As this operation gestalt is shown in drawing 8 , while 14 (referred to as PMT1), 24 (referred to as PMT2), and 54 (referred to as PMT3) use three PMT and arranging in the shape of abbreviation for T characters Voltage FOROA 60, 62, and 64 of FET is formed in the output of each PMT 14, 24, and 54 as an FET probe. The output of this voltage FOROA 60, 62, and 64 is inputted into the coincidence detector 72 through discriminators (disc) 66, 68, and 70. Only when triple coincidence is able to be taken in this coincidence detector 72, the output of each PMT 14, 24, and 54 is incorporated applying a trigger to the digital oscilloscope 40.

[0039] In drawing, 52 is the scintillator (for example, BaF2) prepared in the close side of PMT54.

[0040] It is putting the signal of an FET probe into desk RIMITETA and a coincidence detector in this operation gestalt using voltage FOROA (FET probe) 60, 62, and 64 and the coincidence detector 72. Only when PMT 1-3 catches mostly all of both a nucleus gamma ray and a positron annihilation gamma ray to coincidence (for example, less than 50ns), it inputs a trigger signal into the digital oscilloscope 40. Since the data point of PMT 1-3 is incorporated and he is trying to transmit to PC46, the burden of the digital oscilloscope 40 is mitigable. In addition, when capacity of the digital oscilloscope 40 is large-capacity-ized, it is also possible to omit voltage FOROA and a coincidence detector and to incorporate all data of all in the digital oscilloscope 40.

[0041] In this operation gestalt, PMT 14, 24, and 54 caught all three gamma rays (start signal) of 1.275MeV(s) and gamma rays (stop signal) of 0.511MeV(s), and the start and the stop are distinguished later in the case of the waveform analysis in PC46.

[0042] Here, the combination of an usable start and a stop is PMT1(start)-PMT2 (stop).
PMT2(start)-PMT1 (stop)
PMT1(start)-PMT3 (stop)
PMT3(start)-PMT1 (stop)
Since it is four kinds of **, a counting rate improves to 2x2=4 time compared with the 1st operation gestalt. In addition, since both the gamma ray of 1.275MeV and the gamma ray of 0.511MeV may go into a scintillator, the combination of PMT2 and PMT3 cannot be used.

[0043] Next, the 3rd operation gestalt of this invention is explained to a detail.

[0044] This operation gestalt detects all four gamma rays (start signal) of 1.275MeV and gamma rays (stop signal) of 0.511MeV, and distinguishes a start and a stop later in the case of waveform analysis while 14, 24, 54, and 84 (referred to as PMT4) use four PMT and it arranges it in an abbreviation cross-joint configuration, as shown in drawing 9 .

[0045] In drawing, 82 is the scintillator (for example, BaF2) prepared in the close side of PMT84.

[0046] According to this operation gestalt, a counting rate improves to 4x2=8 time (the reason which does not increase 4x3 times is as by the way the 3rd operation gestalt having explained.).

[0047] In addition, neither the number of PMT nor a role assignment is limited to said

operation gestalt, but three to four PMT is used, and three to one of the remainder [three / of three to four / one to] the gamma ray (start signal) of 1.275MeV(s) and of three to four can catch the gamma ray (stop signal) of 0.511MeV(s).

[0048] Next, the 5th thru/or the 7th operation gestalt which caught the incidence of positive electron, the nucleus gamma ray (1.275MeV) from 22Na which appears in coincidence, and two positron annihilation gamma rays (0.511MeV) is explained.

[0049] As the 5th operation gestalt of this invention is shown in drawing 10 , using three PMT 14, 24, and 54, PMT1 catches the gamma ray (start signal) of 1.275MeV(s), and PMT2 and PMT3 catch the gamma ray (stop signal) of 0.511MeV(s), respectively.

[0050] In this case, since it can average to one event after measuring two time amount, time resolution improves.

[0051] In addition, like the 6th operation gestalt which the number of PMT is not limited to three, for example, is shown in drawing 11 , using PMT, PMT1 and PMT4 catch the gamma ray (start signal) of 1.275MeV(s), and PMT2 and PMT3 can catch four gamma rays (stop signal) of 0.511MeV(s), respectively.

[0052] In this case, compared with the 5th operation gestalt, a counting rate improves twice.

[0053] Moreover, he is trying for PMT 1-4 to catch both the gamma ray (start signal) of 1.275MeV(s), and the gamma ray (stop signal) of 0.511MeV with the 7th operation gestalt of this invention in a configuration as shown in the same drawing 11 as the 6th operation gestalt.

[0054] In this case, compared with the 5th operation gestalt, a counting rate improves by 4 times.

[0055] In addition, in said operation gestalt, although each used directly the radioisotope (RI) which emits positive electron as a source of positive electron, the class of source of positive electron is not limited to this. Moreover, it is not limited to that for which the candidate for application of this invention also uses RI directly, but also when carrying out the positive electron emitted from RI beam-ization (low-speed positive electron beam) and using it, it can use. In this case, it is necessary to make artificially the start signal acquired from each gamma ray (1.275MeV) from RI which appears in the incidence and coincidence of positive electron. Usually, the low-speed positive electron beam is formed into a short pulse by applying velocity modulation to a positive electron beam using RF cavity resonator (refer to JP,5-74593,A), an induction system (for example, refer to JP,11-281793,A), etc. Then, the same effectiveness (improvement in time resolution and improvement in a counting rate) is expectable by replacing the timing signal at the time of forming a short pulse with PMT used for the start signal of said operation gestalt.

[0056]

[Effect of the Invention] According to this invention, PMT was able to set at least two to 150 or less pses by that they were 200ps(es)'s transposing CFD, TAC, and MCA to a digital oscilloscope like the 1st operation gestalt by the case where the half-value width of time resolution is the best, and performing suitable wave processing conventionally. Furthermore, time resolution was able to be improved to 120 or less pses by catching both of positron annihilation gamma rays, using PMT three or more.

[0057] Moreover, it was able to improve by 8 times [the conventional approach using PMT] also about the counting rate by two. That is, in catching two gamma rays,

compared with the former, measurement effectiveness improves by 8 times by using four PMT. Moreover, in catching three gamma rays, measurement effectiveness improves by 4 times from the time of using three PMT by using four PMT.

[0058] Furthermore, the SN ratio was also able to improve.

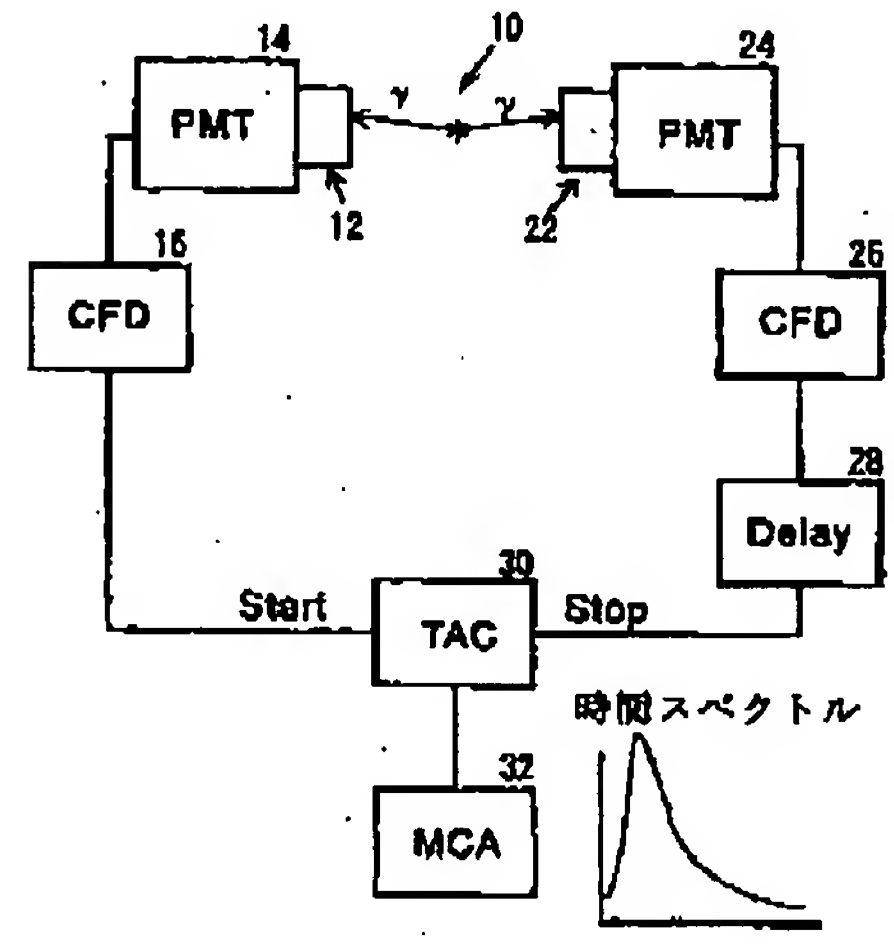


FIG 1

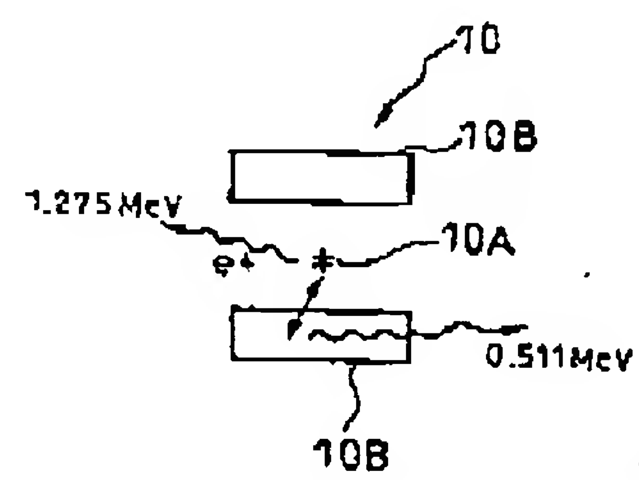


FIG 2

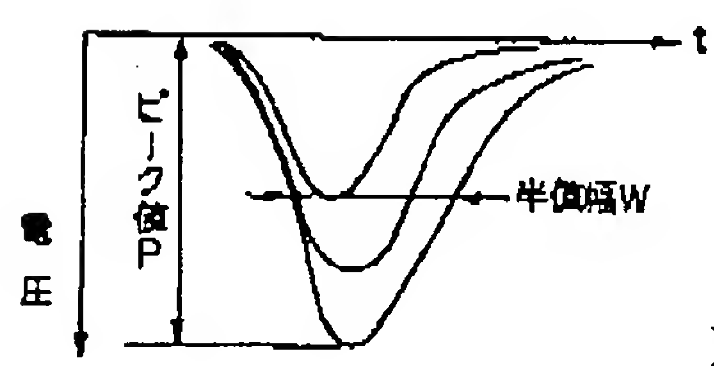


FIG 3

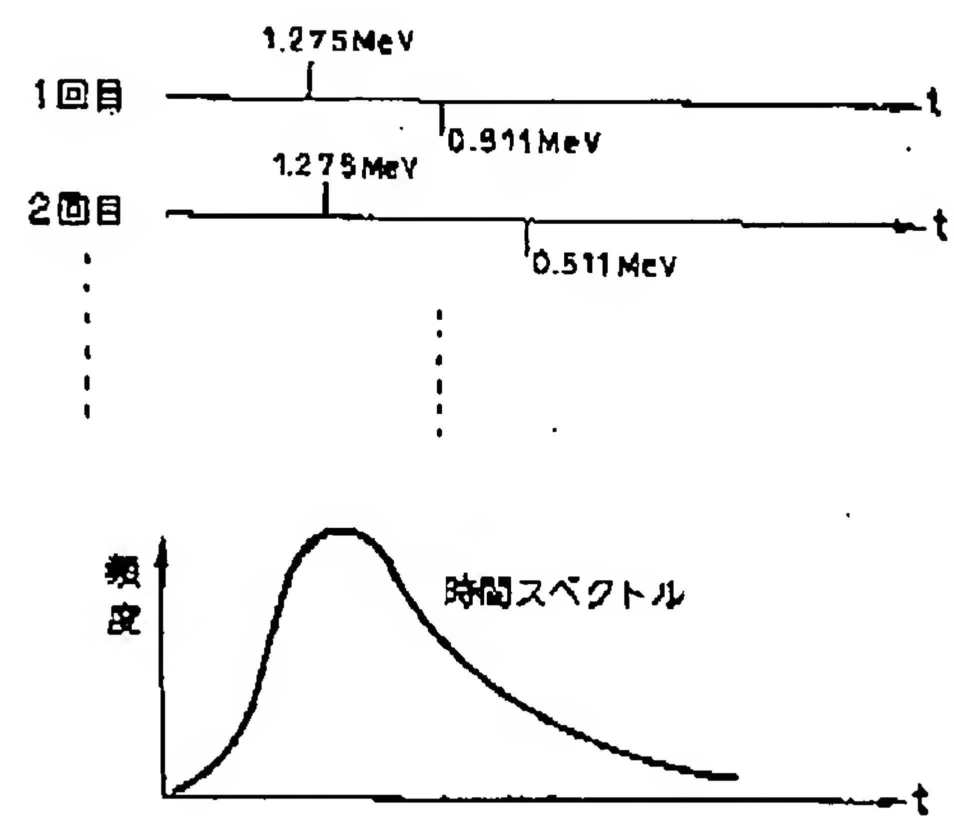


FIG 4

JP 2003-215251

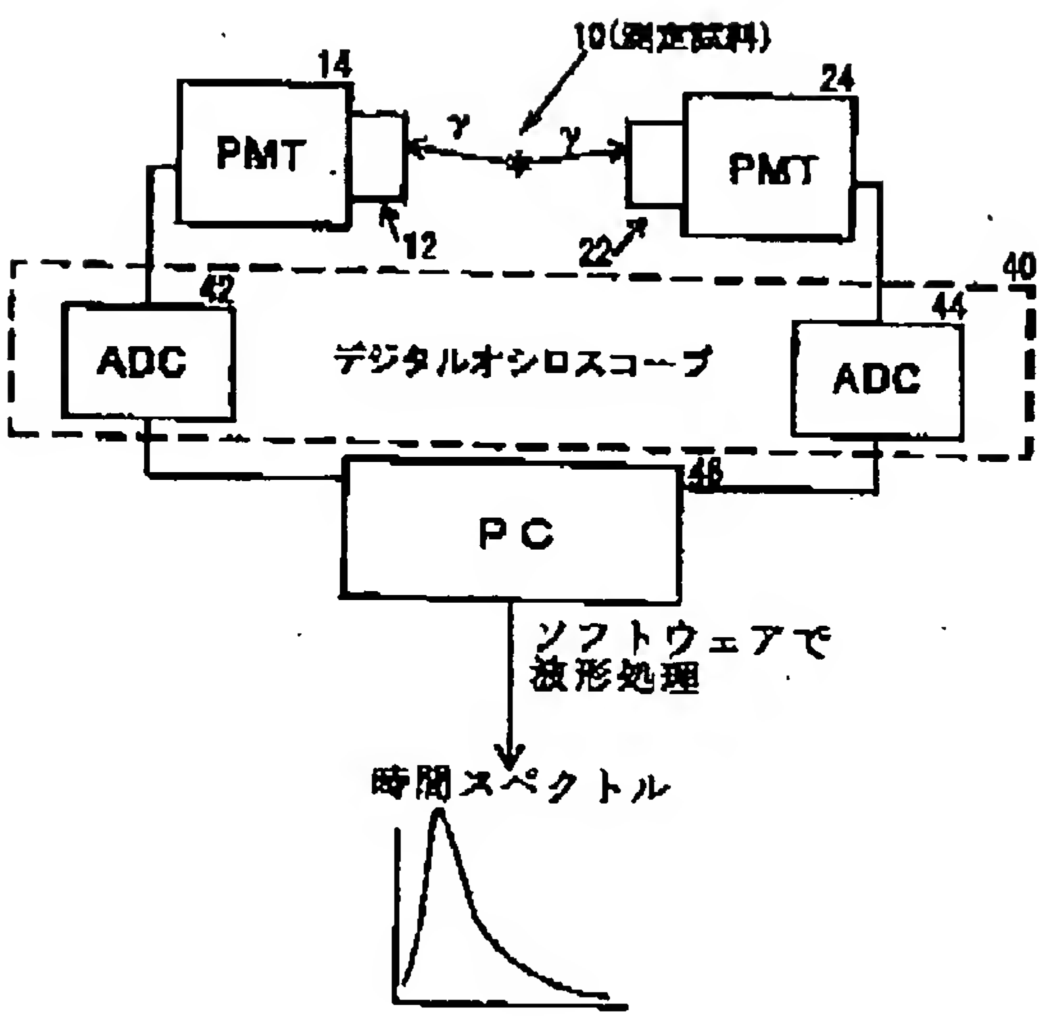


FIG 5

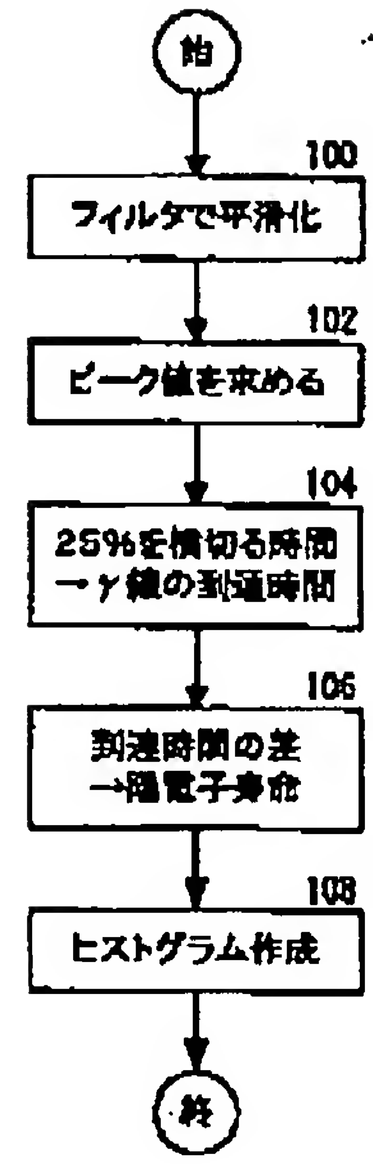


FIG 6

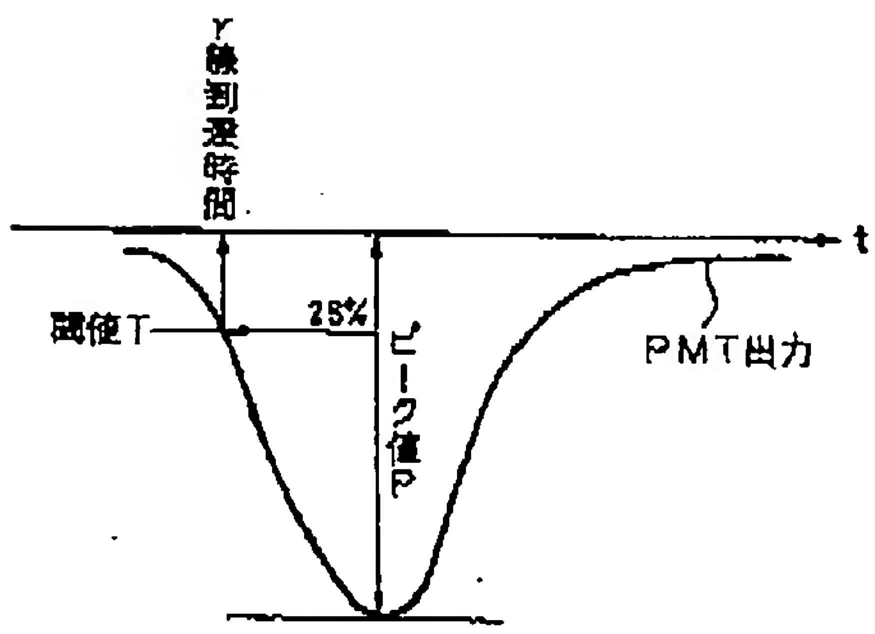


FIG 7

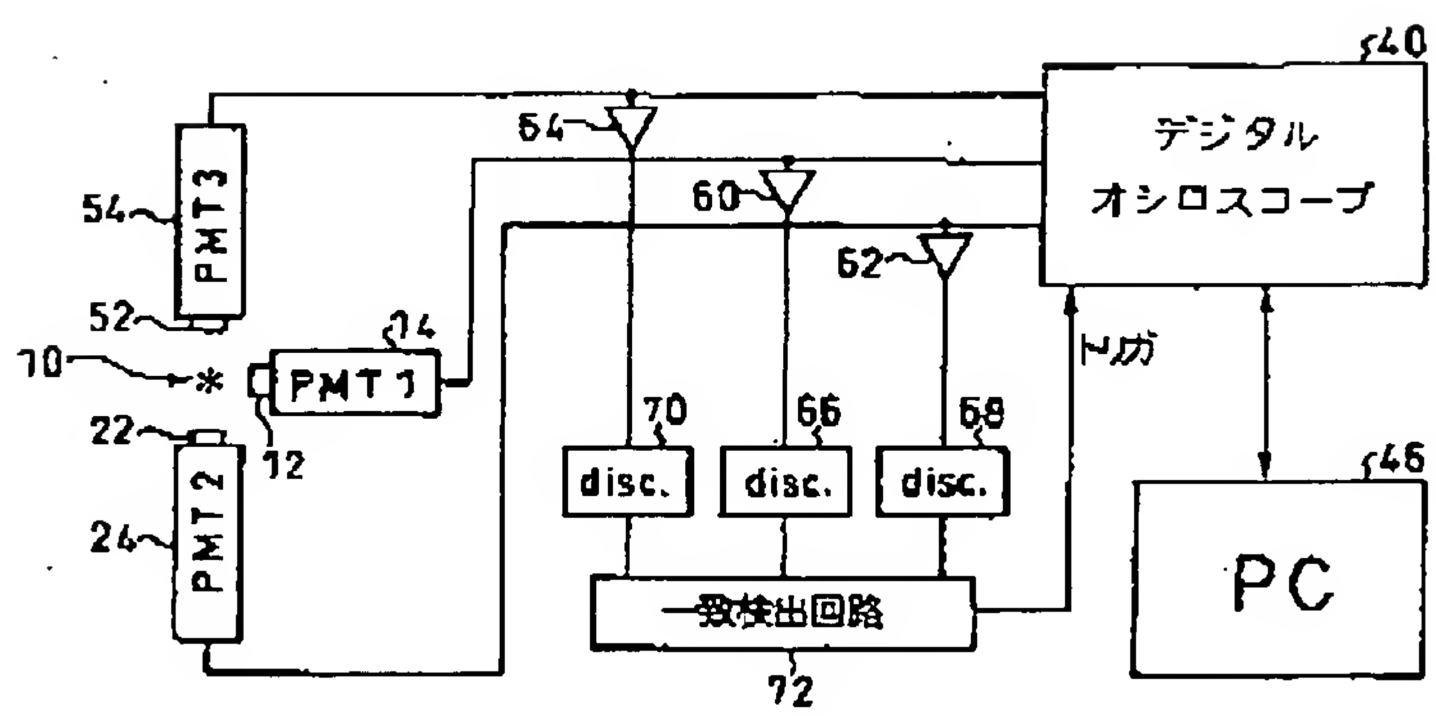


FIG 8

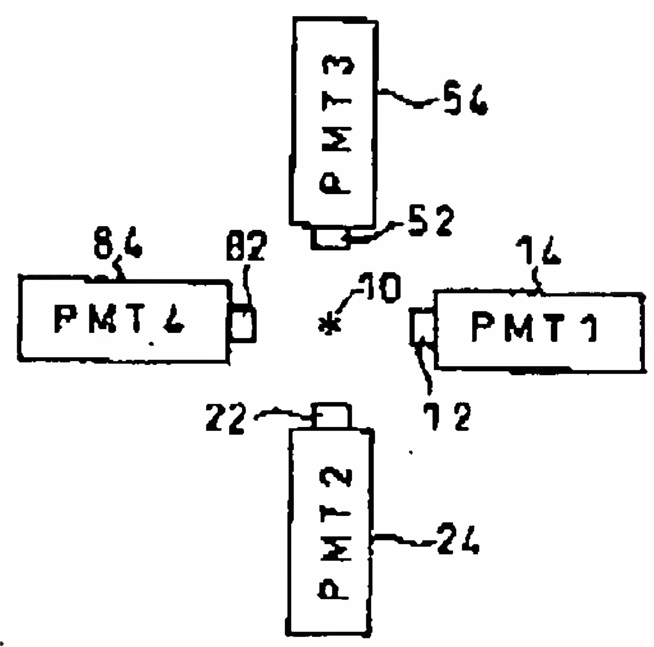


FIG 9

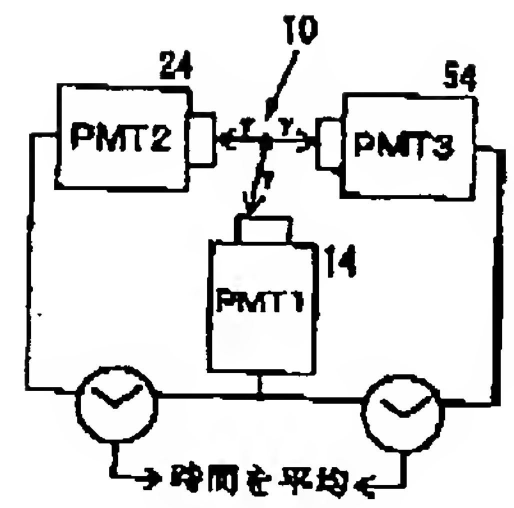


FIG 10

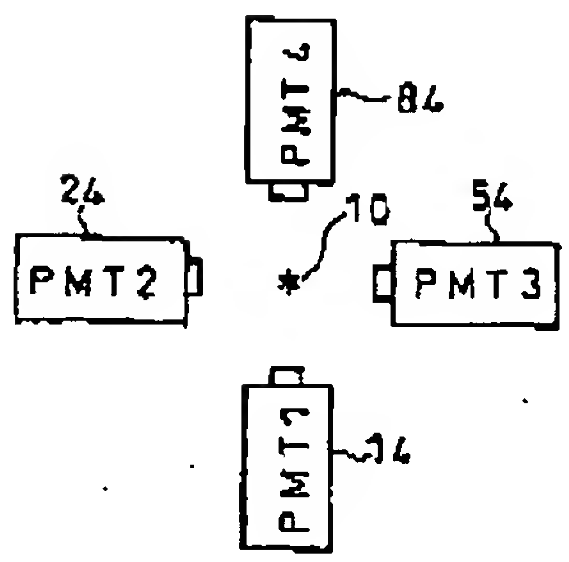


FIG 11